THE EELWORM DISEASE OF WHEAT AND ITS CONTROL

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In cooperation with the Office of Cereal Investigations

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A Sound Head of Wheat between Two Diseased Heads

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THE EELWORM DISEASE of wheat, long known in Europe, has been found causing considerable damage in Virginia and in isolated localities in West Virginia, Maryland, Georgia, and California.

Every effort should be made to control the trouble in these infested regions, to prevent its further spread, and to find other localities where the disease may exist.

The disease may be recognized on young and old plants and in the thrashed wheat by the descriptions given in this bulletin.

The trouble may be controlled by the use of clean seed, by crop rotation, and by sanitation.

If clean seed can not be procured from uninfested localities, diseased seed can be made safe for planting by the salt-brine treatment here described.

THE EELWORM DISEASE OF WHEAT AND ITS CONTROL.[1]

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A SERIOUS DISEASE of wheat,[2] long known in Europe and caused by a nematode, or eelworm,[3] has been found causing a great deal of damage in certain parts of the United States, particularly in Virginia. Fortunately, the trouble can be controlled by measures which are described in this bulletin.

DESCRIPTION OF THE DISEASE.

The disease is usually brought to notice by its effects on wheat heads in the field, although it may occur on all parts of the plant above ground. Young plants a few inches high affected with the trouble can usually be readily recognized by a decided wrinkling, rolling, and distortion of the upper leaves, as shown in figure 1. Such plants may die or may remain alive and produce dwarfed, diseased heads. These heads ordinarily stay green longer—that is, ripen later—and are smaller than those not affected, and the chaff is likely to open out at a wider angle than that of the good heads. In place of the expected good grains of wheat the head bears dark, hard galls, shorter and somewhat thicker than wheat grains, and, since the chaff spreads open, these can often be plainly seen in the affected spikelets before the thrashing. As these galls bear a resemblance to cockle, the seed of a common grainfield weed, farmers have mistakenly applied the name "cockle" to these galls, and "cockle wheat" is a common term for this disease in the thrashed grain. Sometimes it has been mistaken for bunt, or stinking smut, a disease caused by a fungus related to the common loose smuts of

[1] The writer is the specialist in charge of the investigations of the nematode diseases of cotton, truck, and forage crops. This bulletin is published as a contribution from the Office of Cereal Investigations because wheat is a cereal crop.

[2] A more complete and technical treatise on this disease, under the title "The Nematode Disease of Wheat Caused by Tylenchus tritici," will be found in Bulletin 842 of the United States Department of Agriculture.

[3] *Tylenchus tritici* (Steinbuch) Bastian is the scientific name of the nematode causing this disease.

corn and small grains. It has also been confused with bin-burnt wheat, caused by overheating in storage. A careful examination of these different troubles, as illustrated in figures 2, 4, 5, and 6, will show that this nematode disease is entirely distinct. In addition to wheat, it has been found that rye, oats, spelt, and emmer are also

FIG. 1.—Wheat seedlings infected with the eelworm disease. Note the wrinkling, rolling, and twisting of the leaves.

attacked by the disease. On these the effects of the disease are similar to those described for wheat.

CAUSE OF THE DISEASE.

Within these wheat galls are thousands of living but motionless young nematodes, as brought out in figure 7, which shows a section through a gall. These young nematodes are called larvæ

and can be barely seen as short, threadlike fibers when placed in water. In water the living larvæ soon begin active movement.

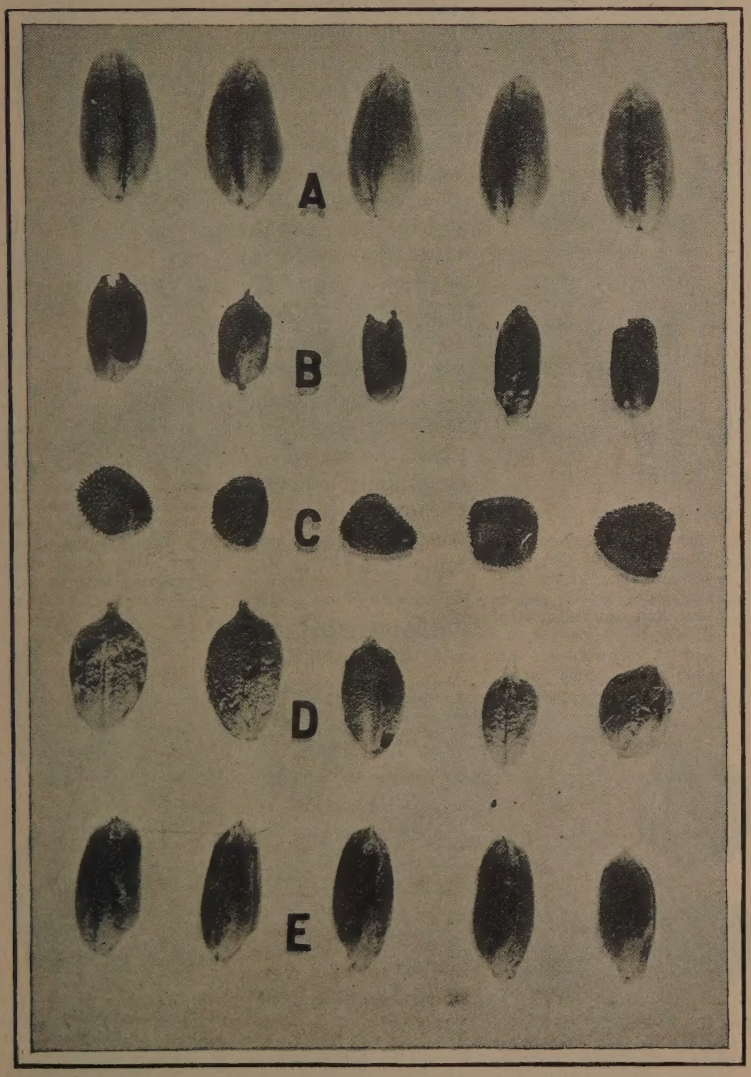

FIG. 2.—Compare the sound wheat (*A*) with the eelworm-containing galls (*B*) and note the difference between these smooth galls and the spiny seeds of cockle (*C*), the smutted wheat grains (*D*), and the bin-burnt kernels (*E*). (About 2¾ times natural size.)

These larvæ are shown, greatly enlarged, in figure 8. These young eelworms escape into the soil from galls which have fallen to the

ground or which were planted along with the wheat seed. With an eellike movement they reach the young seedling, finally become located between the leaf sheaths near the bud, and as the plant grows are gradually carried up to the heads. There they enter the young flowers and produce the galls. Within these they grow to maturity and lay eggs, which give rise to larvæ. In this way their life cycle is completed. At the maturity of the plant the larvæ become dried out and motionless, in which condition they can remain alive for many years.

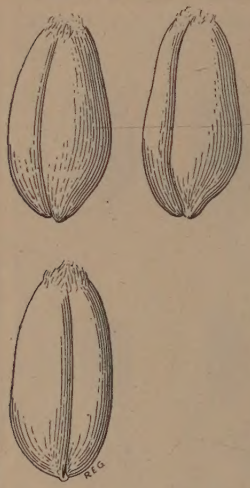

FIG. 3.—Plump, sound wheat kernels about five times natural size, for comparison with the nematode galls, cockle seed, and smutted grains shown in figures 4, 5, and 6, respectively, at about the same magnification.

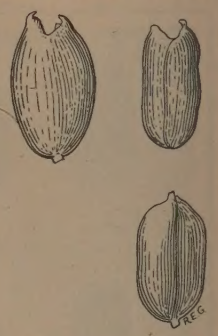

FIG. 4.—Eelworm galls of wheat which are produced in diseased heads instead of good grains. Notice that they are decidedly different in shape, size, and form from the seed of cockle and the smutted grains shown in figures 5 and 6, and yet they are often confused with these.

DISTRIBUTION AND IMPORTANCE.

In the United States the disease was first reported to occur to a slight extent in 1909 in California, New York, West Virginia, and Georgia. After that time nothing is known about the occurrence of the trouble until 1917, when it was located at one place in Virginia, and since then it has been found at many points in the same State; also in West Virginia, Maryland, and Georgia, and in one locality in California. Samples of wheat mixed with the nematode galls

FIG. 5.—Seeds of cockle. This is a common grainfield weed, the seeds of which are frequently thrashed with the wheat and because of a general similarity have been mistaken for eelworm galls.

FIG. 6.—Smutted grains of wheat. These grains are very light and can be easily crushed between the fingers into a smutty black powder. In this way they can be readily distinguished from the eelworm galls, which are hard.

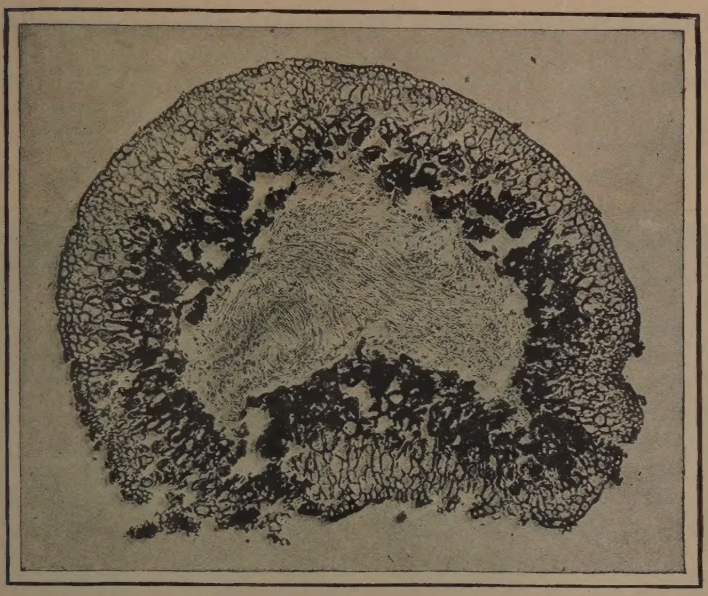

FIG. 7.—Reproduction from a photograph, taken through a microscope, of a thin cross section of an eelworm gall. The section is magnified about 35 times and shows a thick wall of cells surrounding the almost colorless mass of threadlike eelworm larvæ in the center. Under favorable moisture and temperature conditions in the field these larvæ escape from the gall into the soil and attack the young wheat plants. In figure 8 some of the active larvæ are shown greatly enlarged.

FIG. 8.—Reproduction from a photograph, taken through a microscope, showing a number of the minute eelworm larvæ barely one twenty-fifth of an inch long which have been taken from a gall and placed in a drop of water. They are here shown enlarged about 30 times. The worms move actively with an eellike motion, and for this reason are called eelworms.

collected at Virginia mills in 1918 and 1919 indicate that the disease caused a loss of more than 25 per cent in a number of fields. In the thrashed grain from one field in Virginia an examination of the 1918 crop showed as much as a 70 per cent loss by actual count.

Although the present known distribution of the trouble is comparatively limited, it seems highly probable that it has been spread

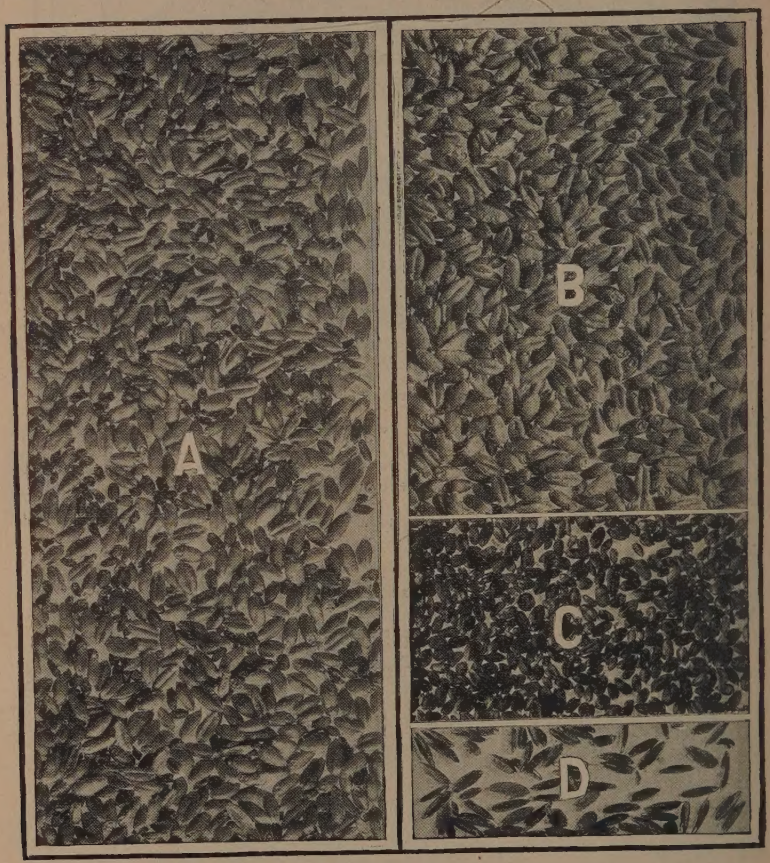

FIG. 9.—Wheat before and after treatment: *A*, A sample of wheat collected at the thrashing machine, which contains about 50 per cent of eelworm galls; *B*, clean wheat separated from eelworm galls by the salt-brine method, as explained in the text; *C*, eelworm galls; *D*, light, shriveled kernels and other matter floated off by the salt-brine method.

to other wheat-growing regions in the interchange of seed and along with importations of seed from foreign countries, in many of which the disease is widespread. Very likely the trouble occurs to some extent in other States and has been either overlooked or mistaken for bunt, cockle seed, or bin-burnt wheat. An examination of wheat

before or after thrashing should yield valuable information on this point. Samples of wheat or grain thought to be affected with this disease should be sent for positive identification to the agricultural experiment station of the State in which the disease is found or to the Office of Cereal Investigations, United States Department of Agriculture, Washington, D. C.

CONTROL OF THE DISEASE.

As the disease is not native to the United States, every effort should be made to prevent its further spread within this country, to stamp

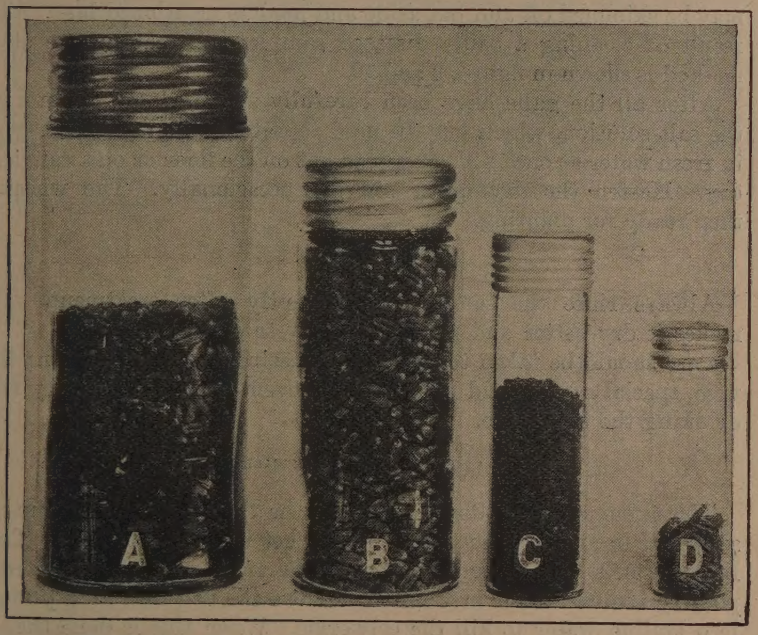

FIG. 10.—Wheat before and after treatment. In the large jar (*A*) is shown a 2-ounce sample of wheat from Virginia before treatment by the salt-brine method. Jars *B*, *C*, and *D* contain a similar sample after being treated by the salt-brine method and separated into (*B*) sound, plump grains, (*C*) nematode galls, and (*D*) light shriveled kernels, smutted grains, etc. The sample contains nearly as many eelworm galls (959) as plump grains (1,395), but the former occupy only about one-third the space of the sound grains.

it out in localities infested, and to stop its further introduction from foreign countries. It may be controlled by the measures suggested later.

CLEAN SEED.

Secure, when possible, clean, sound seed from fields in which the disease does not occur and which therefore is free from the nematode galls.

HOW TO CLEAN DISEASED SEED.

If disease-free seed can not be obtained from uninfested localities, the galls may be separated from the wheat kernels by the so-called salt-brine method devised by Dr. A. G. Johnson, of Wisconsin, for removing ergot from rye. Essentially it is as follows:

First, make up a 20 per cent salt solution by dissolving 40 pounds of common salt in 25 gallons of water. Then pour the diseased seed slowly into this solution, stirring vigorously at the same time. The sound wheat kernels will sink, while the nematode galls, light kernels, and trash will float. The galls and other floating material may be skimmed off and put aside and used as mentioned later. The result of cleaning a badly diseased sample of wheat by the above method is shown in figures 9 and 10.

After all the galls have been carefully skimmed off, drain away the salt solution, which may be used repeatedly, and rinse the grain in fresh water at once. Then spread out on the floor or on a canvas to dry. Hasten the drying by stirring occasionally. The wheat is then ready for planting.

PRECAUTIONS.

Always rinse the sound seed promptly after treatment. This makes it dry better and prevents injury to germination.

Care should be taken to avoid the freezing of the wet grain; likewise, special care should be taken to prevent stock and poultry from drinking the salt brine.

DISPOSAL OF EELWORM GALLS.

The skimmed-off galls should never be thrown on the ground or scattered in any way so that they can get back on the land. These light kernels and other skimmed-off material can safely be fed to poultry if first rinsed in water to remove the salt and then plunged into boiling water to kill the eelworms. When this is done there is no danger of the eelworms remaining alive or the poultry being injured. Whether or not the galls are fed to poultry, they should be plunged in hot water before being thrown out anywhere.

CROP ROTATION.

As this nematode disease of wheat also attacks rye, oats, spelt and emmer, land on which nematode-infected grain has been grown should be planted to other crops for two or, better still, three years. During this time the nematode will be starved out so that subsequent grain crops grown from clean seed will be free from the trouble, or practically so. Any other crops may be used in the rotation, as only these grains are known to be attacked by the disease.

The experience of a farmer in Virginia, when the wrong rotation was followed, is of especial interest.[1] His 1918 wheat crop was very heavily infected with the nematode disease. Rye was sown on this field and a heavy nematode infection of the rye resulted in 1919. This infection, of course, came from the nematodes remaining in the soil from the 1918 diseased wheat crop. Susceptible crops should be kept off infested land at least two years, and better still for three years.

SANITATION.

Care should be taken to prevent the spread of the nematode from one field to another by means of infested soil which may cling to the feet of men or animals, or to various kinds of farm implements. Surface waters, which may carry galls or the free nematodes, should not be permitted to pass from infested soils to uninfested areas. A deep plowing under of the stubble just after harvest lessens the spread of the disease either to near-by fields or within the same field.

[1] An account of this was given by F. D. Fromme and R. C. Thomas, of the Virginia Agricultural Experiment Station.

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